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(71) Applicant: OPUSWAVE NETWORKS, INC. [US/US]; 1365 Garden of the Gods Rd., Colorado Springs, CO 80907 (US).

(72) Inventors: LYON, James; 8390 Sutterfield Dr., Colorado Springs, CO 80920 (US). HOWSER, Steve; 429 N. Nevada Ave. #3, Colorado Springs, CO 80903 (US). MENON, Narayan; 5910 Bay Springs Lane, Colorado Springs, CO 80918 (US).

(74) Agents: KALER, Stuart, P. et al.; Siemens Corporation, Intellectual Property Dept., 186 Wood Avenue South, Iselin, NJ 08830 (US).

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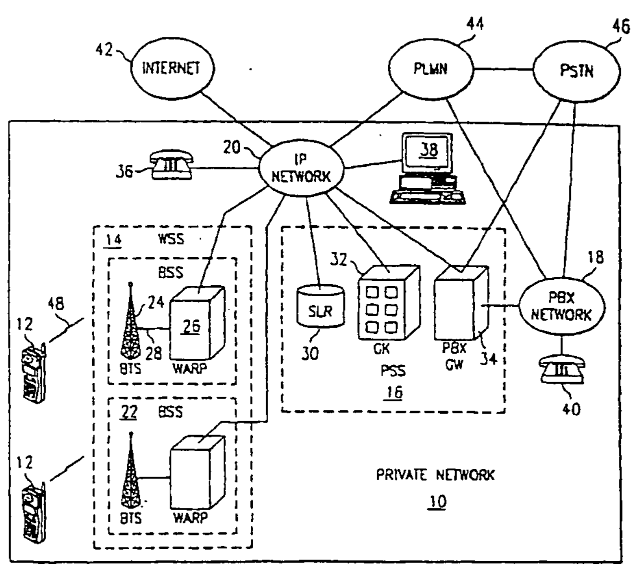

(57) **Abstract:** A system for interworking voice bearer messages between circuit-switched and packet-switched networks includes a base station (24) operable to communicate with a mobile station (12) over a wireless interface (48). The system also includes a wireless adjunct internet platform (WARP) (26) coupled to the base station (24) and to the packet-switched network (20). The WARP (26) is operable to communicate with the mobile station (12) through the base station (24) using a circuit-switched protocol and with the packet-switched network (20) using a packet-switched protocol. The WARP (26) comprises an interworking function operable to convert between the circuit-switched protocol and the packet-switched protocol.

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METHOD AND SYSTEM FOR INTERWORKING CIRCUIT-SWITCHED AND PACKET-SWITCHED NETWORKS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the following applications:

U.S. Application Serial No. 09/128,553, filed on August 3, 1998, and entitled "A 'Plug and Play' Wireless Architecture Supporting Packet Data and IP Voice/Multimedia Services," pending; and

U.S. Application Serial No. 09/219,539, filed on December 23, 1998, and entitled "Wireless Local Loop System Supporting Voice/IP," pending.

All of the following applications are related:

U.S. Application Serial No. 09/499,921, filed concurrently herewith, and entitled "Method and System for Interworking Voice Bearer Messages Between Circuit-Switched and Packet-Switched Networks," pending;

U.S. Application Serial No. 09/499,923, filed concurrently herewith, and entitled "Method and System for Interworking Voice Signaling Messages Between Circuit-Switched and Packet-Switched Networks," pending;

U.S. Application Serial No. 09/500,751, filed concurrently herewith, and entitled "Method and System for Incorporating Legacy Private Branch Exchange Features in a Wireless Network," pending;

U.S. Application Serial No. 09/500,379, filed concurrently herewith, and entitled "Method and System for Providing User Mobility Between Public and Private Wireless Networks," pending; and

U.S. Application Serial No. 09/499,922, filed concurrently herewith, and entitled "Method and System for Providing Management Protocol Mediation in Wireless Communications Networks," pending.

These applications have been commonly assigned to Opuswave Networks, Inc.

TECHNICAL FIELD OF THE INVENTION

This invention relates generally to the field of telecommunications and, more specifically, to a method and system for interworking voice bearer messages between circuit-switched and packet-switched networks.

BACKGROUND OF THE INVENTION

Private branch exchanges, or PBXs, are well-known in the art of telecommunications. Corporations, organizations, and other enterprises typically use PBXs to provide internal telephone services to their personnel. The personnel may call one another without using an external switched public telephone network, although the PBX is coupled to the public telephone networks for making external local and long distance calls. Telephones are usually coupled to the PBX by wireline connections. PBXs also typically implement a variety of features, including call waiting, call forwarding, conferencing, and call blocking.

Packet-switched computer networks are also common. Corporations and other enterprises typically use the computer networks to provide computer and data services to their personnel. The networks often take the form of a Local Area Network (LAN), a Wide Area Network (WAN), or a Metropolitan Area Network (MAN). These networks typically are used to transfer and share data files and to send and receive e-mail. In addition, developments in the area of Voice over IP (VoIP) allow the packet-switched networks to transmit voice messages.

Recently, interest in wireless networks has increased. Wireless networks allow mobile stations, or wireless units, to communicate over a wireless interface. The mobile station may be a wireless telephone communicating with a voice network over the wireless interface. The mobile station may also be a computer communicating with a data network over the wireless interface. Wireless communications may be over private or public networks. Operators of the wireless networks often wish to integrate the wireless networks into the existing PBXs and computer networks.

The PBX, wireless network, and computer network are usually separate networks since each of them often uses different protocols to transfer messages and manage elements of the network. The inability to fully integrate the wireless network

with the PBX and computer network inhibits the wireless network from performing several key functions. Without full integration, mobile station users may have difficulty accessing the PBX and the computer network. Also, the mobile station users may not be able to roam between the private wireless network and the public wireless network. The mobile station user cannot move in and out of the private wireless network while talking. Instead, the user has to terminate the call, move to the other network, and reestablish a connection. In addition, the inability to fully integrate the networks may force the mobile station users to have two different wireless phones, one for the private wireless network and one for the public wireless network. Further, to provide PBX features in a wireless network, the wireless network operator typically installs substantial hardware and/or software in the wireless network to provide these features. However, even though the PBX-like features are implemented in the wireless network, the PBX and the wireless network still remain separate.

SUMMARY OF THE INVENTION

In accordance with the present invention, a method and system for interworking voice bearer messages between circuit-switched and packet-switched networks is provided that substantially eliminates or reduces disadvantages and problems associated with previously developed systems and methods.

A system for interworking voice bearer messages between circuit-switched and packet-switched networks is disclosed. The system comprises a base station operable to communicate with a mobile station over a wireless interface. The system also comprises a wireless adjunct internet platform (WARP) coupled to the base station and to the packet-switched network. The WARP is operable to communicate with the mobile station through the base station using a circuit-switched protocol and with the packet-switched network using a packet-switched protocol. The WARP comprises an interworking function operable to convert between the circuit-switched protocol and the packet-switched protocol.

A method of interworking voice bearer messages between circuit-switched and packet-switched networks is also disclosed. The method comprises the step of transmitting and receiving circuit-switched bearer messages to and from a mobile

station over a wireless interface using a circuit-switched protocol. The method also comprises the step of transmitting and receiving packet-switched bearer messages to and from the packet-switched network using a packet-switched protocol. The method further comprises the step of interworking the circuit-switched and the packet-switched protocols.

A technical advantage of the present invention is that the wireless network can work with an existing PBX, eliminating any need to remove or replace the existing PBX. This reduces the cost of the equipment and the cost of installing the wireless network. Another technical advantage of the present invention is that the wireless network, once integrated into the other networks, can make use of the features currently installed in the existing PBX. In addition, mobile station users only need one wireless phone, rather than one for the public wireless network and one for the private wireless network. Further, the wireless network can be fully integrated with the existing PBX and the computer network, even though the networks may use different message transfer and management protocols. Mobile stations can use the existing PBX to gain access to external voice networks like the public phone systems, and the mobile stations can use the computer network to gain access to external data networks like the Internet. The mobile station users may also roam between the private wireless network and the public wireless network without terminating a call and reestablishing a connection.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and for further features and advantages, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 illustrates a private communications network, including a wireless adjunct internet platform (WARP) and a PBX gateway, coupled to existing public and private voice and data networks in accordance with the teachings of the present invention;

FIGURE 2 illustrates, in greater detail, the WARP of FIGURE 1;

FIGURE 3 illustrates the different protocols used to send bearer and signaling messages through the communications network of FIGURE 1;

FIGURE 4 illustrates, in greater detail, the architecture of the signaling plane used to control the establishment, maintenance, and release of a voice call from a wireless mobile station to another wireless mobile station;

FIGURE 5 illustrates, in greater detail, the architecture of the signaling plane used to control the establishment, maintenance, and release of a voice call from a wireless mobile station to a PBX;

FIGURE 6 illustrates, in greater detail, the architecture of the voice bearer plane used to transmit a voice bearer message from a wireless mobile station to another wireless mobile station;

FIGURE 7 illustrates, in greater detail, the architecture of the voice bearer plane used to transmit a voice bearer message from a wireless mobile station to a PBX;

FIGURE 8 is a flowchart illustrating an interworking function performed by the WARP of FIGURE 1; and

FIGURE 9 is a flowchart illustrating another interworking function performed by the WARP of FIGURE 1.

DETAILED DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention and its advantages are best understood by referring to FIGURES 1 through 9 of the drawings, like numerals being used for like and corresponding parts of the various drawings.

FIGURE 1 illustrates a private communications network coupled to existing public and private voice and data networks in accordance with the teachings of the present invention. Private network 10 comprises one or more mobile stations (MS) 12, a wireless subsystem (WSS) 14, a packet switching subsystem (PSS) 16, a private branch exchange (PBX) 18, and an Internet Protocol (IP) network 20.

Two planes of operation are used to transmit a voice signal from mobile station 12 through private network 10. One plane is a bearer plane, and the other plane is a signaling plane. The bearer plane carries voice bearer messages that contain the voice signal. The signaling plane carries call control messages needed to establish, maintain, and release a voice call through private network 10.

Different protocols may be used by devices in the same plane to transmit bearer or signaling messages in private network 10. The protocols could include, for example, circuit-switched protocols like the Global System for Mobile communication (GSM) 04.08 and 08.60 protocols, and a packet-switched protocol such as the International Telecommunications Union-Telecommunications (ITU-T) H.323 protocol.

Mobile station 12 comprises any device capable of communicating with a base station 24 over a wireless interface 48. Mobile station 12 may comprise, for example, a GSM mobile station capable of delivering a circuit-switched speech service. Alternatively, mobile station 12 may comprise a portable computer with a microphone or a phone coupled to a wireless modem. Mobile station 12 may also comprise a computer and a phone coupled to a radio unit. In this document, the terms "couple," "coupled," and "coupling" refer to any direct or indirect connection between two elements within private network 10, whether or not the two elements are in physical contact with one another.

Wireless subsystem 14 comprises one or more base station subsystems (BSS) 22. Each base station subsystem 22 comprises a base transceiver station (BTS) 24, also called a base station 24, and a wireless adjunct internet platform (WARP) 26.

Base station 24 is coupled to WARP 26 by an interface 28. Base station 24 also provides bi-directional communication with mobile station 12 in a specified geographic area over wireless interface 48. Base station 24 is operable to transfer messages between mobile station 12 and WARP 26. Base station 24 may comprise, for example, one or more transceivers capable of transmitting and receiving circuit-switched messages from mobile station 12 over wireless interface 48. In one embodiment, base station 24 and mobile station 12 communicate using the GSM 04.08 signaling message and 08.60 bearer message protocols.

Wireless interface 48 couples mobile station 12 and base station 24. In this document, the term "wireless" designates the use of a radio or over-the-air interface to communicate with mobile station 12. Wireless interface 48 may comprise any of a number of available wireless interfaces capable of transferring circuit-switched bearer and signaling messages between mobile station 12 and base station 24. In one embodiment, mobile station 12 and base station 24 communicate using the GSM General Packet Radio Service (GSM/GPRS) interface. In another embodiment, base

station 24 and mobile station 12 communicate using the GSM Enhanced Data rates for GSM Evolution (GSM/EDGE) interface.

WARP 26 is coupled to base station 24 by interface 28 and to IP network 20. WARP 26 allows users of mobile stations 12 to gain access to internal networks and to external voice and data networks. In one embodiment, WARP 26 communicates with mobile station 12 through base station 24 using a circuit-switched message protocol, and WARP 26 communicates with IP network 20 using a packet-switched message protocol. WARP 26 also provides interworking for the transmission of messages through private network 10. WARP 26 translates between the circuit-switched and the packet-switched protocols. In one embodiment, WARP 26 converts circuit-switched messages from mobile station 12 into packetized messages suitable for transmission over IP network 20. WARP 26 also converts packetized messages from IP network 20 into circuit-switched messages sent to mobile station 12. In a particular embodiment, WARP 26 uses the architecture specified in the ITU-T H.323 protocol standard for provisioning IP packet voice services.

Interface 28 couples base station 24 and WARP 26. Interface 28 may be any of a number of available interfaces capable of transferring circuit-switched bearer and signaling messages between base station 24 and WARP 26. Interface 28 may comprise, for example, a GSM Abis wireline interface.

IP network 20 transmits and receives packet-switched messages from one address in IP network 20 to another address. IP network 20 may comprise any number of available packet-switched networks. IP network 20 may, for example, comprise a Local Area Network or a Wide Area Network. An IP phone 36 and a workstation 38 may also be coupled to IP network 20. IP network 20 may also be coupled to an external data network such as Internet 42 or to an external voice network like a public land mobile network (PLMN) 44.

Packet switching subsystem 16 comprises a subscriber location register (SLR) 30, a gatekeeper (GK) 32, and a PBX gateway (GW) 34. Subscriber location register 30 is coupled to IP network 20. Subscriber location register 30 stores subscriber management information for each mobile station 12. Subscriber location register 30 stores general subscriber management information downloaded from PLMN 44. Subscriber location register 30 also stores each user's extension number, direct dial number, and any other information that is specific to private network 10. Subscriber

location register 30 may comprise, for example, a SUN^{TM} workstation with a database.

PBX gateway 34 is coupled to IP network 20, a PBX 18, and a public switched telephone network (PSTN) 46. PBX gateway 34 communicates with IP network 20 using a packet-switched message protocol. PBX gateway 34 also communicates with PBX 18 or PSTN 46 using a circuit-switched message protocol. PBX gateway 34 provides the interworking functionality between packet-switched messages transmitted to and received from IP network 20 and circuit-switched messages transmitted to and received from PBX 18 or PSTN 46. In one embodiment, PBX gateway 34 communicates over IP network 20 using the ITU-T H.323 protocol standard, PBX gateway 34 communicates with PBX 18 using a PBX interface protocol, and PBX gateway 34 provides the interworking between the protocols.

Gatekeeper 32 is coupled to IP network 20. Gatekeeper 32 provides call control services for mobile stations 12, WARPs 26, and PBX gateway 34. Gatekeeper 32 tracks the location of each mobile station 12, and gatekeeper 32 routes calls to and from the WARP 26 currently serving a particular mobile station 12. This allows users of mobile stations 12 to roam freely between geographic areas covered by different base stations 24.

PBX 18 is coupled to PBX gateway 34, PLMN 44, and PSTN 46. PBX 18 may transmit and receive circuit-switched voice bearer and signaling messages from PBX gateway 34, PLMN 44, and PSTN 46. PBX 18 may also communicate with a telephone 40 coupled to PBX 18. PBX 18 may be any of a number of available PBX networks capable of transmitting and receiving circuit-switched bearer and signaling messages. PBX 18 may, for example, be a legacy PBX already installed within an existing private network.

In an alternate embodiment of private network 10, private network 10 replaces a legacy PBX 18. In this embodiment, gatekeeper 32 and PBX gateway 34 perform the functions normally implemented in PBX 18.

FIGURE 2 illustrates, in greater detail, the WARP 26 of FIGURE 1. WARP 26 comprises an interface card (IC) 52, a processor card (PC) 54, and a random access memory (RAM) 56. Interface card 52 is coupled to base station 24 through interface 28 and to processor card 54. Interface card 52 transmits and receives circuit-switched signaling and bearer messages between base station 24 and processor card 54.

Interface card 52 may comprise any interface card capable of communicating with base station 24 over interface 28. In one embodiment, base station 24 communicates with interface card 52 over a T1 interface, and interface card 52 comprises a T1 interface card. In another embodiment, interface card 52 comprises a GSM Abis wireline interface card operable to transmit and receive voice bearer messages in GSM Transcoding and Rate Adaptation Unit (TRAU) frames.

Processor card 54 is coupled to interface card 52 and to IP network 20. Processor card 54 performs the interworking between the circuit-switched protocol used by mobile station 12 and the packet-switched protocol used by IP network 20. Processor card 54 may comprise any processor capable of running a real time operating system. In one embodiment, processor card 54 is an INTEL™ PENTIUM™ processor and compatible motherboard.

Random access memory 56 is coupled to processor card 54. RAM 56 is operable to store and retrieve software needed to perform the interworking function and subscriber information associated with each mobile station 12. RAM 56 may comprise, for example, a non-volatile random access memory or any other hardware, software, firmware, or combination thereof capable of storing and retrieving software for processor card 54. In one embodiment, memory 56 comprises 512 megabytes of non-volatile random access memory.

FIGURE 3 illustrates the different protocols used to send bearer and signaling messages through private network 10. Mobile station 12 and WARP 26 exchange a first set of voice bearer or signaling messages using a circuit-switched protocol. In one embodiment, the circuit-switched signaling protocol may be the GSM 04.08 Direct Transfer Application Part (DTAP) protocol.

Gatekeeper/gateway unit 70 represents both gatekeeper 32 and PBX gateway 34. WARP 26 and gatekeeper/gateway unit 70 exchange a second set of voice bearer or signaling messages using a packet-switched protocol. Gatekeeper/gateway unit 70 may also communicate with IP phone 36 over IP network 20 using a packet-switched protocol. In one embodiment, the packet-switched protocol may be the ITU-T H.323 protocol. Further, gatekeeper/gateway unit 70 and telephone 40 may exchange a third set of voice bearer or signaling messages over PBX 18 using a second circuit-switched protocol. The second circuit-switched protocol may be a PBX interface protocol.

Because of the different protocols used, WARP 26 and PBX gateway 34 in gatekeeper/gateway unit 70 provide interworking functions to convert signaling and bearer messages from one protocol to the other. In one embodiment, WARP 26 converts between the ITU-T H.323 protocol and the GSM DTAP protocol, and PBX gateway 34 converts between the ITU-T H.323 protocol and the PBX interface protocol.

FIGURE 4 illustrates one embodiment of the architecture of the signaling plane used to control the establishment, maintenance, and release of a voice call from mobile station 12 to another mobile station 12 in private network 10. The signaling plane comprises a GSM mobile station protocol stack 100, a base transceiver station protocol stack 120, a WARP protocol stack 140, and a gatekeeper protocol stack 180. In one embodiment, signaling messages sent between mobile station 12 and WARP 26 on the signaling plane are based on the GSM 04.08 protocol, and signaling messages sent between WARP 26 and gatekeeper 32 are based on the ITU-T H.323 protocol.

Mobile station protocol stack 100 comprises a physical layer (PHYS) 102, a data link control (DLC) layer 104, a radio resource (RR) management layer 106, and a GSM Connection Management and Mobility Management (GSM CC/MM) layer 108. Base transceiver station protocol stack 120 comprises a physical layer 122, a data link control layer 124, a radio resource management layer 126, a T1/E1 protocol layer 128, an L2 protocol layer 130, and a base transceiver station management (BTSM) layer 132.

WARP protocol stack 140 comprises a T1/E1 protocol layer 142, an L2 protocol layer 144, a base transceiver station management layer 146, a radio resource management layer 148, a GSM connection management and mobility management layer 150, an interworking function (IWF) layer 152, an H.225 call control (CC) protocol layer 154, an H.245 protocol layer 156, an H.323 Registration, Admissions, and Status (RAS) protocol layer 158, a Transmission Control Protocol (TCP) layer 160, a User Datagram Protocol (UDP) layer 162, an Internet Protocol (IP) layer 164, a subnetwork layer 166, and a physical layer 168.

Gatekeeper protocol stack 180 comprises a physical layer 182, a subnetwork layer 184, an Internet Protocol layer 186, two UDP layers 188 and 206, a TCP layer

190, two H.323 RAS protocol layers 192 and 204, two H.245 protocol layers 194 and 202, two H.225 call control protocol layers 196 and 200, and a relay layer 198.

Physical layers 102 and 122 manage wireless interface 48 between mobile station 12 and base station 24. Data link control layers 104 and 124 and radio resource management layers 106 and 126 allow private network 10 to establish, maintain, and release GSM-managed circuits on wireless interface 48. GSM connection management and mobility management layers 108 and 150 support the transfer of connection and mobility management information between mobile station 12 and WARP 26.

T1/E1 protocol layers 128 and 142 and L2 protocol layers 130 and 144 allow private network 10 to manage the transmission of signaling messages between base station 24 and WARP 26 using T1/E1 and L2 transmission protocols. BTSM layers 132 and 146 allow private network 10 to establish, maintain, and release GSM-managed circuits on wireless interface 48 between mobile station 12 and base station 24.

Interworking function layer 152 in WARP 26 performs the interworking between the circuit-switched signaling protocol used by mobile station 12 and the packet-switched signaling protocol used by IP network 20. The H.225 call control protocol layers 154, 196, and 200 manage the transmission of call control and feature invocation messages. The H.245 protocol layers 156, 194, and 202 manage the allocation and deallocation of logical channels over the interface between IP network 20 and WARP 26 and between IP network 20 and PBX gateway 34. The H.323 RAS layers 158, 192, and 204 support Registration, Admissions, and Status protocol processing by WARP 26 and gatekeeper 32, which includes discovery, management, and location management procedures.

TCP layers 160 and 190 and Internet Protocol layers 164 and 186 manage and support TCP/IP connections between WARP 26 and gatekeeper 32. The UDP layers 162, 190, and 206, together with Internet Protocol layers 164 and 186, manage and support UDP/IP connections between WARP 26 and gatekeeper 32. The UDP/IP connections are used to transmit Registration, Admissions, and Status signaling messages, and the TCP/IP connections are used to transmit other signaling messages.

Subnetwork protocol layers 166 and 184 support subnetwork transmission protocols for transmitting packet-switched signaling messages between WARP 26 and

gatekeeper 32. In one embodiment, subnetwork protocol layers 166 and 184 may be ethernet layers. Physical layers 168 and 182 support the management of the physical transmission interface between WARP 26 and gatekeeper 32.

Relay layer 198 supports the transfer of signaling messages to and from WARPs 26. Because WARPs 26 may communicate with one another using a packet-switched message protocol, no interworking function is required, and gatekeeper 32 acts as a relay for the signaling messages.

FIGURE 5 illustrates one embodiment of the architecture of the signaling plane used to control the establishment, maintenance, and release of a voice call from mobile station 12 to PBX gateway 34. The architecture of mobile station 12, base station 24, WARP 26, and gatekeeper 32 shown in FIGURE 5 is the same as in FIGURE 4. In addition, a PBX gateway protocol stack 220 comprises a physical layer 222, a subnetwork layer 224, an Internet Protocol layer 226, a TCP layer 228, an H.245 protocol layer 230, an H.225 call control protocol layer 232, an interworking function layer 234, a PBX interface layer 236, and a physical layer 238.

Physical layer 222 supports the management of the physical transmission interface between gatekeeper 32 and PBX gateway 34. Subnetwork protocol layer 224 supports subnetwork transmission protocols for transmitting packet-switched signaling messages between gatekeeper 32 and PBX gateway 34. TCP layer 228 and Internet Protocol layer 226 manage and support TCP/IP connections between gatekeeper 32 and PBX gateway 34. The H.245 protocol layer 230 manages the allocation and deallocation of logical channels over the interface between IP network 20 and WARP 26 and between IP network 20 and PBX gateway 34. The H.225 call control protocol layer 232 manages the transmission of call control and feature invocation messages. Interworking function layer 234 supports the interworking between the packet-switched message protocol used by IP network 20 and the circuit-switched message protocol used by PBX 18. PBX interface layer 236 provides the physical transmission interface between PBX gateway 34 and PBX 18 for the transmission of signaling messages. Physical layer 238 supports the management of PBX interface 236.

FIGURE 6 illustrates one embodiment of the architecture of the voice bearer plane used to transmit voice bearer messages from mobile station 12 to another mobile station 12 in private network 10. The voice bearer plane comprises a GSM

mobile station protocol stack 260, a base transceiver station protocol stack 280, and a WARP protocol stack 300. In one embodiment, bearer messages sent on the voice bearer plane between mobile station 12 and WARP 26 are based on the GSM 08.60 protocol, and bearer messages sent between WARPs 26 are based on the ITU-T H.323 protocol.

Mobile station protocol stack 260 comprises a physical layer 262 and a vocoder layer 264. Base transceiver station protocol stack 280 comprises a physical layer 282, a T1/E1 protocol layer 284, and a GSM 08.60 protocol layer 286. WARP protocol layer 300 comprises a T1/E1 protocol layer 302, a GSM 08.60 protocol layer 304, an interworking function layer 305, a Real Time Protocol/RTP Control Protocol (RTP/RTCP) layer 306, a UDP layer 308, an Internet Protocol layer 310, a subnetwork protocol layer 312, and a physical layer 314.

Physical layers 262 and 282 manage wireless interface 48 between mobile station 12 and base station 24. In one embodiment, physical layers 262 and 282 support a GSM General Packet Radio Service (GSM/GPRS) interface. In another embodiment, physical layers 262 and 282 support a GSM Enhanced Data rates for GSM Evolution (GSM/EDGE) interface.

T1/E1 protocol layers 284 and 302 and GSM 08.60 protocol layers 286 and 304 support the transmission of voice bearer messages between base station 24 and WARP 26 using standard T1/E1 and GSM 08.60 transmission protocols. Interworking function layer 305 performs the interworking between the circuit-switched bearer protocol used by mobile station 12 and the packet-switched bearer protocol used by IP network 20.

Subnetwork protocol layer 312 supports subnetwork transmission protocols for transmitting packet-switched voice bearer messages between WARP 26 and IP network 20. Physical layer 314 supports the management of voice bearer message transmissions on the physical transmission interface between WARP 26 and IP network 20.

In one embodiment, mobile stations 12 have an audio codec. Private network 10 may support a variety of coding standards, including G.711, G.722, G.728, G.729, MPEG 1 audio, and G.723.1. The specific encoding algorithm used by mobile stations 12 is established when a transmitting mobile station 12 transmits capability exchange signaling over the H.245 channel used in the signaling plane, which enables

a receiving mobile station 12 to perform a peer transcoding function. The vocoding function is supported by the vocoder layer 264 of mobile station 12. The peer transcoding function is also supported by the vocoder layer 264 of mobile station 12.

The encoded voice bearer messages may be transmitted over IP network 20 using Real Time Protocol (RTP) packets carried over a UDP/IP connection. The carriage of voice bearer messages over the RTP/UDP/IP connection may be based on the European Telecommunications Standards Institute (ETSI) Telephone and Internet Protocol Harmonization Over Networks (TIPHON) scheme. Transmission of the RTP packets may also be supplemented by the RTP Control Protocol (RTCP) to provide control and identification functionality to private network 10. RTCP also provides feedback between WARPs 26 on the quality of data being sent in the RTP packets. The RTP/RTCP layer 306, UDP layer 308, and Internet Protocol layer 310 support the packetization and transmission functions used in the RTP/UDP/IP transmission of voice bearer signals between WARPs 26.

FIGURE 7 illustrates one embodiment of the architecture of the voice bearer plane used to transmit voice bearer messages from mobile station 12 to PBX gateway 34. The architecture of mobile station 12, base station 24, and WARP 26 shown in FIGURE 7 are the same as in FIGURE 6. In addition, a PBX gateway protocol stack 360 comprises a physical layer 362, a subnetwork layer 364, an Internet Protocol layer 366, a UDP layer 368, a RTP/RTCP layer 370, a vocoder layer 372, an interworking function layer 373, a switched circuit network interface layer 374, and a physical layer 376.

Physical layer 362 supports the management of the physical transmission interface between PBX gateway 34 and IP network 20. Subnetwork protocol layer 364 supports the transmission protocols used to transmit packet-switched voice bearer messages between PBX gateway 34 and IP network 20. Interworking function layer 373 performs the interworking between the circuit-switched bearer protocol used by PBX 18 and the packet-switched bearer protocol used by IP network 20. Switched circuit network interface layer 374 provides the physical transmission interface between PBX gateway 34 and PBX 18 for transmitting and receiving voice bearer messages. Physical layer 376 supports the management of the switched circuit network interface between PBX gateway 34 and PBX 18.

In the RTP/RTCP layer 370, RTCP provides feedback between WARP 26 and PBX gateway 34 on the quality of data being sent in the RTP packets. The RTP/RTCP layer 370, UDP layer 368, and Internet Protocol layer 366 support the packetization and transmission functions used in the RTP/UDP/IP transmission of voice bearer messages between PBX gateway 34 and IP network 20.

As with mobile station 12, PBX gateway 34 supports vocoding functionality. Vocoder layer 372 supports the vocoding function and the peer transcoding function needed to communicate with mobile station 12 through WARP 26.

FIGURE 8 is a flowchart illustrating one embodiment of the interworking function performed by WARP 26. WARP 26 is initialized at a step 400. WARP 26 waits to receive circuit-switched signaling messages from mobile station 12 at a step 402. In one embodiment, mobile station 12 uses the GSM 04.08 message protocol for the signaling messages. The circuit-switched messages may contain an instruction and at least one parameter.

When WARP 26 receives a message from mobile station 12, WARP 26 checks to see if the message contains an instruction that is supported in the packet-switched protocol at a step 404. In one embodiment, WARP 26 checks to see if the GSM 04.08 signaling instruction is supported in the ITU-T H.323 protocol. If not, WARP 26 determines that the circuit-switched message is not supported in the packet-switched protocol at a step 406. WARP 26 may take an appropriate action, such as returning an error message to mobile station 12. WARP 26 then returns to step 402 to await another message from mobile station 12.

If the instruction is supported in the packet-switched protocol, WARP 26 performs an interworking function 407. WARP 26 maps the instruction from the circuit-switched protocol to an equivalent packet-switched protocol instruction at a step 408. WARP 26 maps the parameters sent in the circuit-switched message to equivalent packet-switched parameters at a step 410. WARP 26 composes a packet-switched message using the equivalent packet-switched instruction and parameters at a step 412. WARP 26 transmits the composed packet-switched message to IP network 20 at a step 414. WARP 26 returns to step 402 to await another signaling message from mobile station 12.

FIGURE 9 is a flowchart illustrating one embodiment of another interworking function performed by WARP 26. WARP 26 is initialized at a step 420. WARP 26

waits to receive packet-switched signaling messages from IP network 20 at a step 422. In one embodiment, IP network 20 uses the ITU-T H.323 message protocol for the messages. The packet-switched messages may contain an instruction and at least one parameter.

When WARP 26 receives a message from IP network 20, WARP 26 checks to see if the message contains an instruction that is supported in the circuit-switched protocol at a step 424. In one embodiment, WARP 26 checks to see if the ITU-T H.323 instruction is supported in the GSM 04.08 protocol. If not, WARP 26 determines that the packet-switched message is not supported in the circuit-switched protocol at a step 426. WARP 26 may take an appropriate action, such as returning an error message to IP network 20. WARP 26 then returns to step 422 to await another message from IP network 20.

If the instruction is supported in the circuit-switched protocol, WARP 26 performs an interworking function 427. WARP 26 maps the instruction from the packet-switched protocol to an equivalent circuit-switched protocol instruction at a step 428. WARP 26 maps the parameters sent in the packet-switched message to equivalent circuit-switched parameters at a step 430. WARP 26 composes a circuit-switched message using the equivalent circuit-switched instruction and parameters at a step 432. WARP 26 transmits the composed circuit-switched message to mobile station 12 at a step 434. WARP 26 returns to step 422 to await another signaling message from IP network 20.

The methods shown in FIGURES 8 and 9 show the interworking between circuit-switched and packet-switched signaling messages performed by WARP 26. A similar method is also performed by PBX gateway 34 for interworking circuit-switched signaling messages from PBX 18 and packet-switched messages from IP network 20.

For bearer messages, the interworking function involves packetizing the circuit-switched messages and depacketizing the packet-switched messages. Both WARP 26 and PBX gateway 34 perform this interworking function. In one embodiment, WARP 26 performs the interworking between the GSM 08.60 protocol and the ITU-T H.323 protocol. In a particular embodiment, WARP 26 and PBX gateway 34 communicate over IP network 20 using the Real Time Protocol.

Although an embodiment of the invention and its advantages are described in detail, a person skilled in the art could make various alternations, additions, and omissions without departing from the spirit and scope of the present invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A system for interworking voice bearer messages between circuit-switched and packet-switched networks, which include a voice bearer channel, characterized by:

a base station (24) operable to communicate with a mobile station (12) over a wireless interface (48); and

a wireless adjunct internet platform (WARP) (26) coupled to the base station (24) and to the packet-switched network (20), the WARP (26) operable to communicate with the mobile station (12) through the base station (24) using a circuit-switched protocol and with the packet-switched network (20) using a packet-switched protocol, the WARP (26) comprising an interworking function operable to convert between the circuit-switched protocol and the packet-switched protocol.

2. The system of Claim 1, characterized in that the base station (24) is operable to communicate with a Global System for Mobile communication (GSM) mobile station.

3. The system of Claim 1, characterized in that the circuit-switched protocol comprises a GSM 08.60 protocol.

4. The system of Claim 1, characterized in that the packet-switched protocol comprises an International Telecommunications Union-Telecommunications (ITU-T) H.323 protocol.

5. The system of Claim 1, characterized in that the WARP (26) is coupled to an Internet Protocol (IP) network (20).

6. The system of Claim 5, characterized in that the WARP (26) communicates with the IP network (20) using a Real Time Protocol.

7. The system of Claim 1, further characterized by a gateway (34) coupled to the WARP (26) and to a private branch exchange (PBX) (18), the gateway (34) operable to communicate with the WARP (26) using the packet-switched protocol and with the PBX (18) using a second circuit-switched protocol, the gateway (34) comprising a second interworking function operable to convert between the packet-switched protocol and the second circuit-switched protocol.

8. A wireless adjunct internet platform for interworking voice bearer messages between circuit-switched and packet-switched networks, which include a voice bearer channel, characterized by:

an interface (52) operable to communicate with a mobile station (12) through a base station (24); and

a processor (54) coupled to the interface (52) and operable to communicate with the mobile station (12) using a circuit-switched protocol, the processor (54) also operable to communicate with the packet-switched network (20) using a packet-switched protocol, the processor (52) further operable to perform an interworking function to translate between the circuit-switched protocol and the packet-switched protocol.

9. The wireless adjunct internet platform of Claim 8, characterized in that the interface (52) comprises a GSM Abis wireline interface.

10. The wireless adjunct internet platform of Claim 8, characterized in that the circuit-switched protocol comprises a GSM 08.60 protocol.

11. The wireless adjunct internet platform of Claim 8, characterized in that the packet-switched protocol comprises an ITU-T H.323 protocol.

12. The wireless adjunct internet platform of Claim 8, characterized in that the processor (54) communicates with the packet-switched network (20) using a Real Time Protocol.

13. The wireless adjunct internet platform of Claim 8, further characterized by a random access memory (56) coupled to the processor (54).

14. A method of interworking voice bearer messages between circuit-switched and packet-switched networks, which include a voice bearer channel, characterized by:

transmitting and receiving circuit-switched bearer messages to and from a mobile station (12) over a wireless interface (48) using a circuit-switched protocol;

transmitting and receiving packet-switched bearer messages to and from the packet-switched network (20) using a packet-switched protocol; and

interworking the circuit-switched and the packet-switched protocols.

15. The method of Claim 14, characterized in that the circuit-switched protocol comprises a GSM 08.60 protocol.

16. The method of Claim 14, characterized in that the packet-switched protocol comprises an ITU-T H.323 protocol.

17. The method of Claim 14, characterized in that transmitting and receiving the circuit-switched bearer messages to and from the mobile station (12) over the wireless interface (48) using the circuit-switched protocol comprises:

transmitting and receiving the circuit-switched bearer messages between a base station (24) and the mobile station (12) over the wireless interface (48); and

transmitting and receiving the circuit-switched bearer messages between the base station (24) and a wireless adjunct internet platform (WARP) (26) over a wireline interface (28).

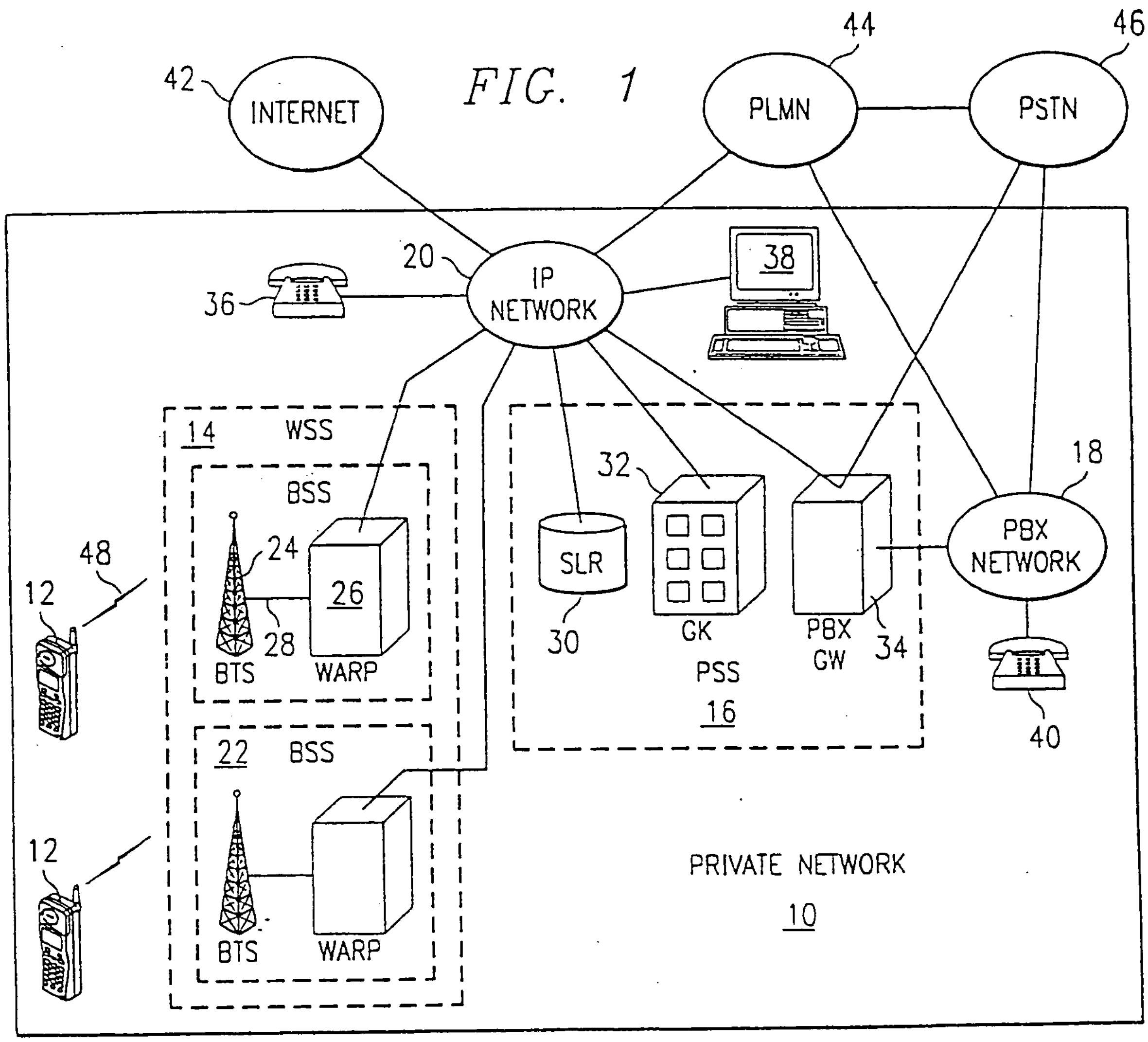
18. The method of Claim 14, characterized in that transmitting and receiving the packet-switched bearer messages to and from the packet-switched network (20) using the packet-switched protocol comprises transmitting and receiving the packet-switched bearer messages between a WARP (26) and the packet-switched network (20).

19. The method of Claim 14, further characterized by transmitting and receiving the packet-switched bearer messages between the packet-switched network (20) and a gateway (34).

20. The method of Claim 19, further characterized by:

transmitting and receiving circuit-switched bearer messages using a second circuit-switched protocol between the gateway (34) and a private branch exchange (18); and

interworking the second circuit-switched and the packet-switched protocols.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PLMN
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PSTN
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BSS
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BTS
WARP
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PSS
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18
PBX
NETWORK
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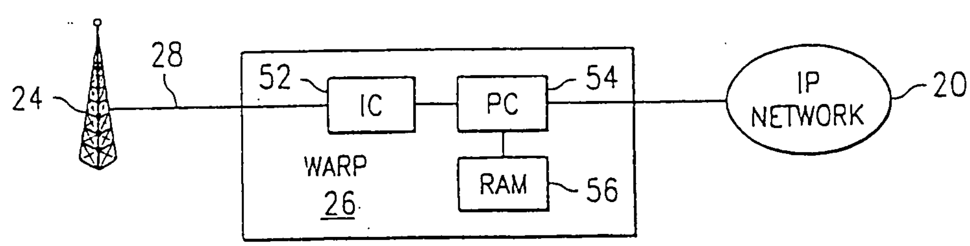
PRIVATE NETWORK
10

FIG. 1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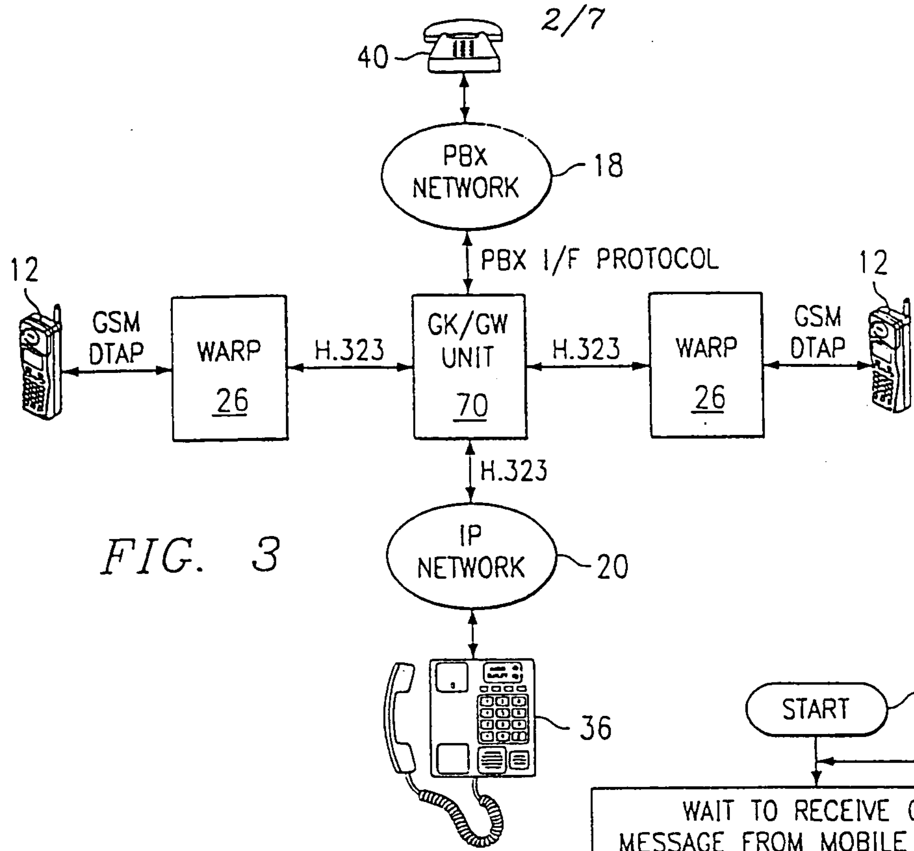
NETWORK
20

FIG. 2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12
H.323
IP
NETWORK
20
36

FIG. 3

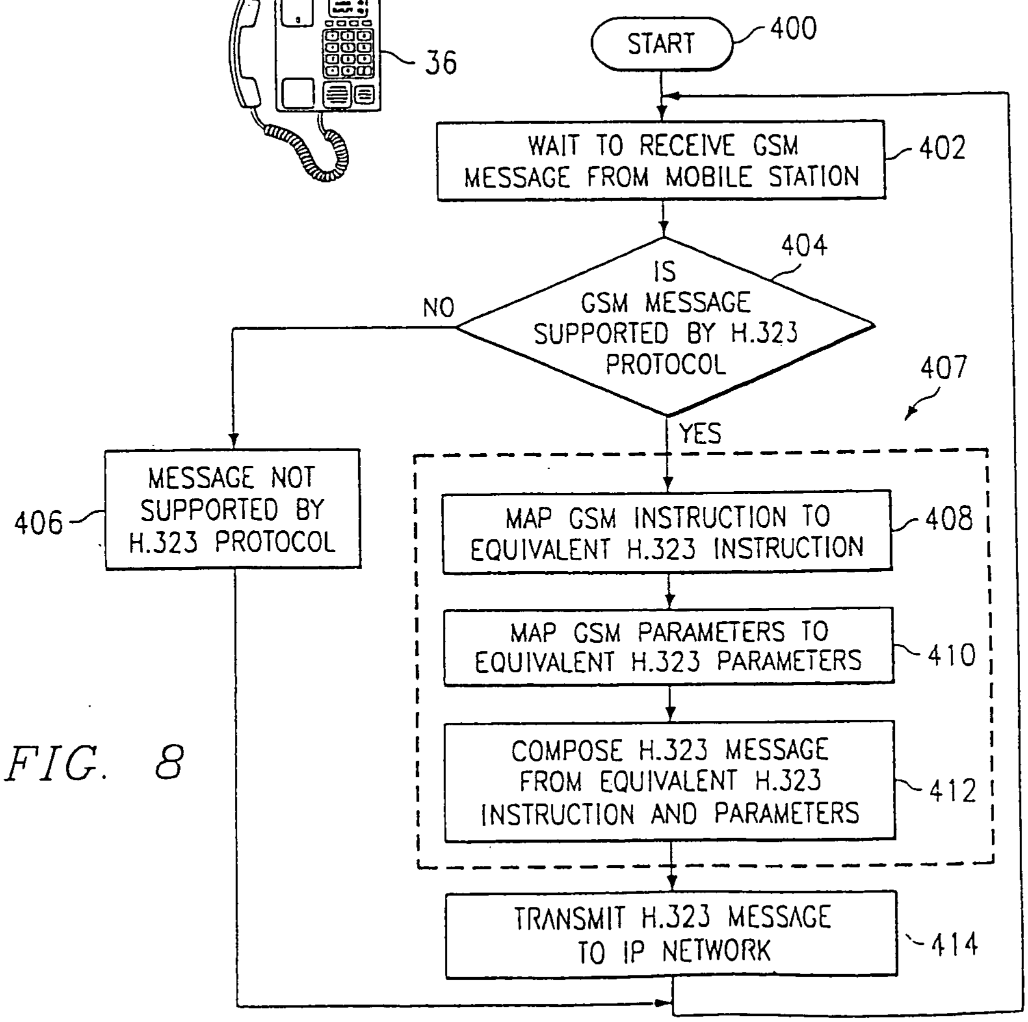
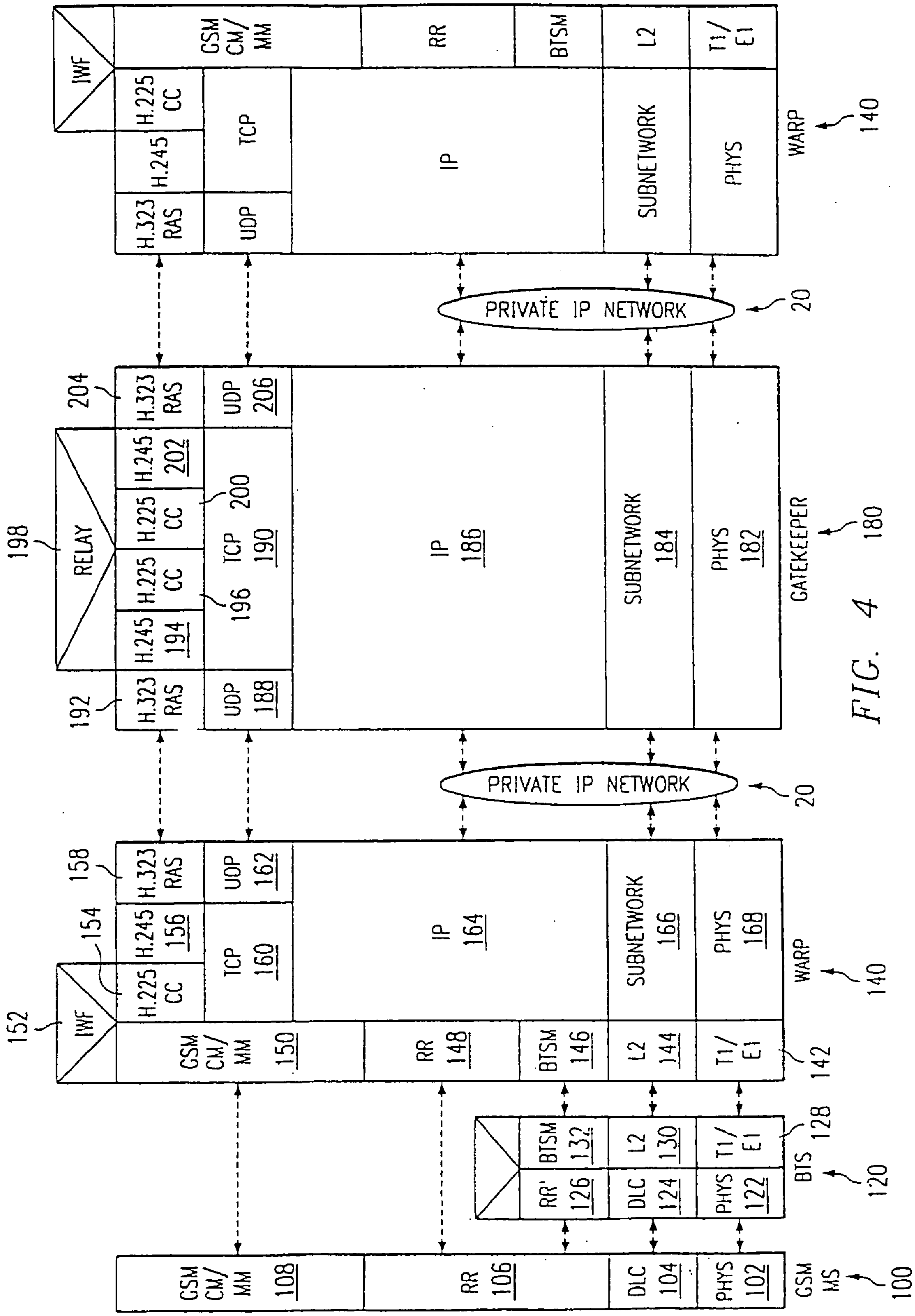

START
400
WAIT TO RECEIVE GSM MESSAGE FROM MOBILE STATION
402
IS GSM MESSAGE SUPPORTED BY H.323 PROTOCOL
404
NO
YES
407
MESSAGE NOT SUPPORTED BY H.323 PROTOCOL
406
MAP GSM INSTRUCTION TO EQUIVALENT H.323 INSTRUCTION
408
MAP GSM PARAMETERS TO EQUIVALENT H.323 PARAMETERS
410
COMPOSE H.323 MESSAGE FROM EQUIVALENT H.323 INSTRUCTION AND PARAMETERS
412
TRANSMIT H.323 MESSAGE TO IP NETWORK
414

FIG. 8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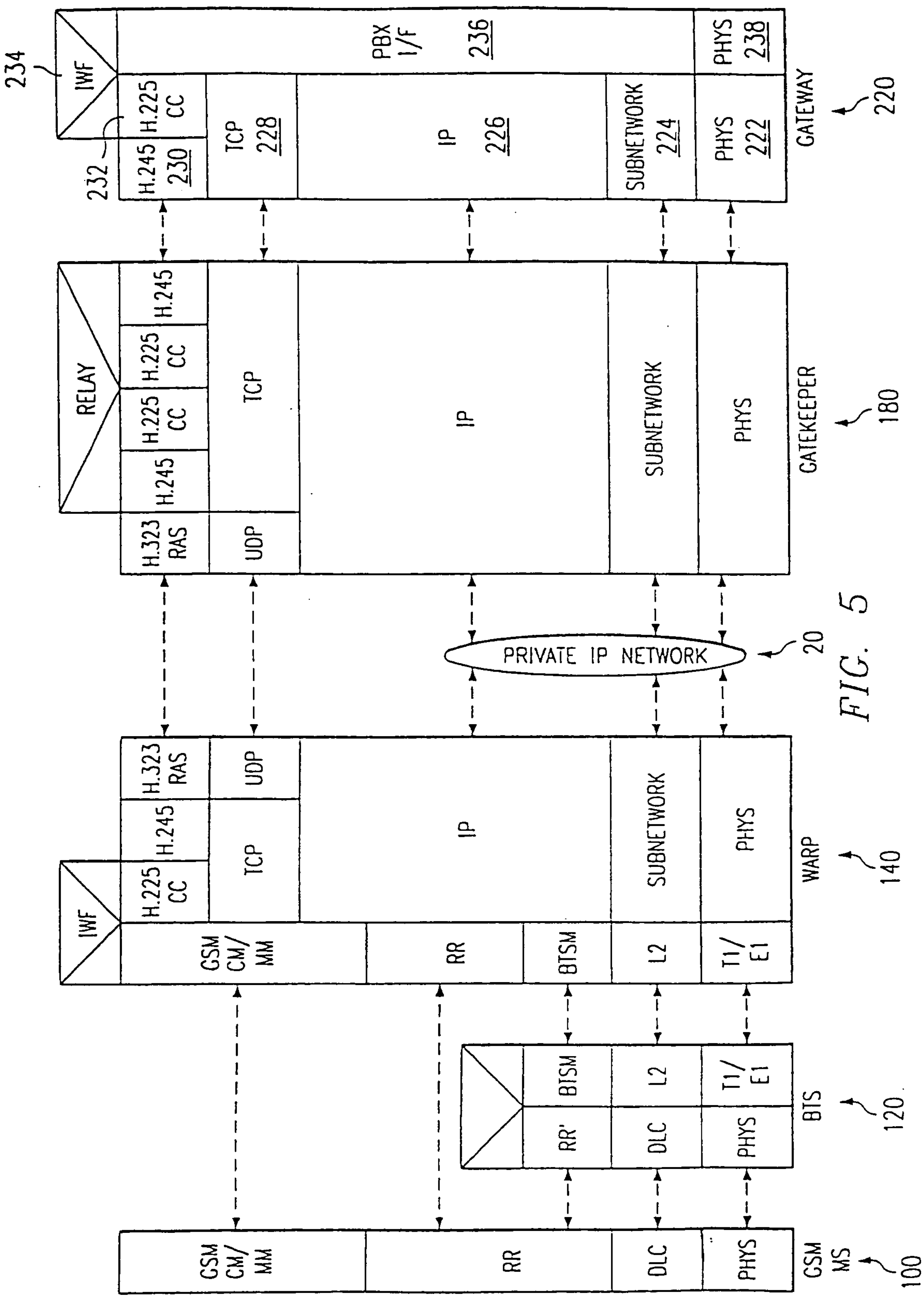
GSM CM/ MM
H.225 CC
H.245
H.323 RAS
TCP
UDP
RR
IP
BTSM
L2
SUBNETWORK
T1/ E1
PHYS
WARP
140
PRIVATE IP NETWORK
20
204
H.323 RAS
UDP 206
198
RELAY
H.245 202
H.225 CC
200
TCP 190
H.225 CC
196
H.245 194
192
H.323 RAS
UDP 188
IP 186
SUBNETWORK 184
PHYS 182
GATEKEEPER
180
PRIVATE IP NETWORK
20
158
H.323 RAS
UDP 162
154
H.245 156
H.225 CC
TCP 160
IP 164
SUBNETWORK 166
PHYS 168
WARP
140
152
IWF
GSM CM/ MM 150
RR 148
BTSM 146
L2 144
T1/ E1
142
BTSM 132
L2 130
T1/ E1
128
RR' 126
DLC 124
PHYS 122
BTS
120
GSM CM/ MM 108
RR 106
DLC 104
PHYS 102
GSM MS
100

FIG. 4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PBX I/F 236
PHYS 238
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H.245 230
H.225 CC
TCP 228
IP 226
SUBNETWORK 224
PHYS 222
GATEWAY
220
RELAY
H.245
H.225 CC
H.225 CC
H.245
TCP
H.323 RAS
UDP
IP
SUBNETWORK
PHYS
GATEKEEPER
180
PRIVATE IP NETWORK
20
IWF
H.225 CC
H.245
H.323 RAS
TCP
UDP
IP
SUBNETWORK
PHYS
GSM CM/MM
RR
BTSM
L2
T1/E1
WARP
140
BTSM
L2
T1/E1
RR'
DLC
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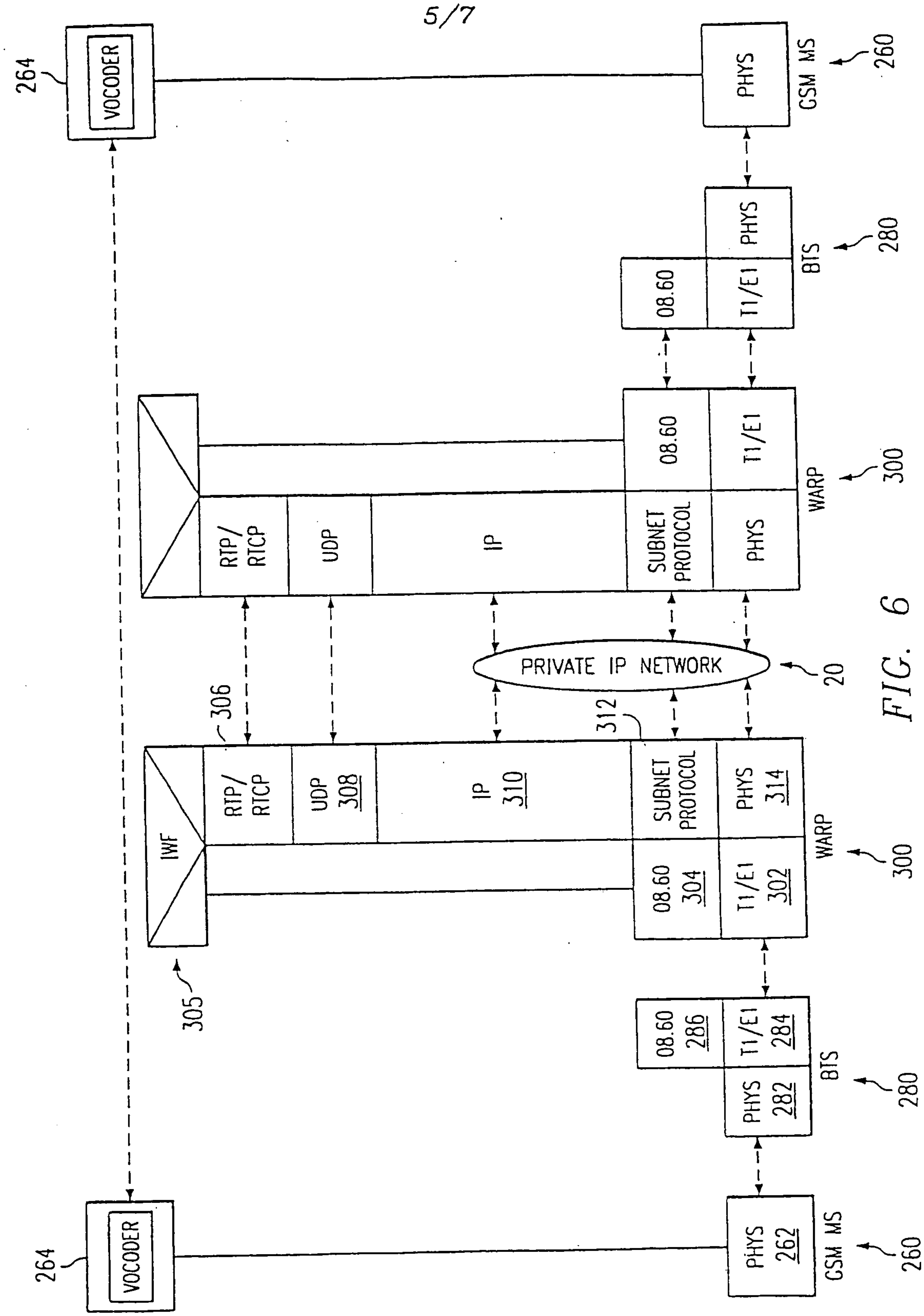
BTS
120
GSM CM/MM
RR
DLC
PHYS
GSM MS
100

FIG. 5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GSM MS
260
PHYS
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T1/E1
BTS
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T1/E1
RTP/
RTCP
UDP
IP
SUBNET
PROTOCOL
PHYS
WARP
300
PRIVATE IP NETWORK
20
306
312
IWF
RTP/
RTCP
UDP
308
IP
310
SUBNET
PROTOCOL
PHYS
314
08.60
304
T1/E1
302
WARP
300
305
08.60
286
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PHYS
282
BTS
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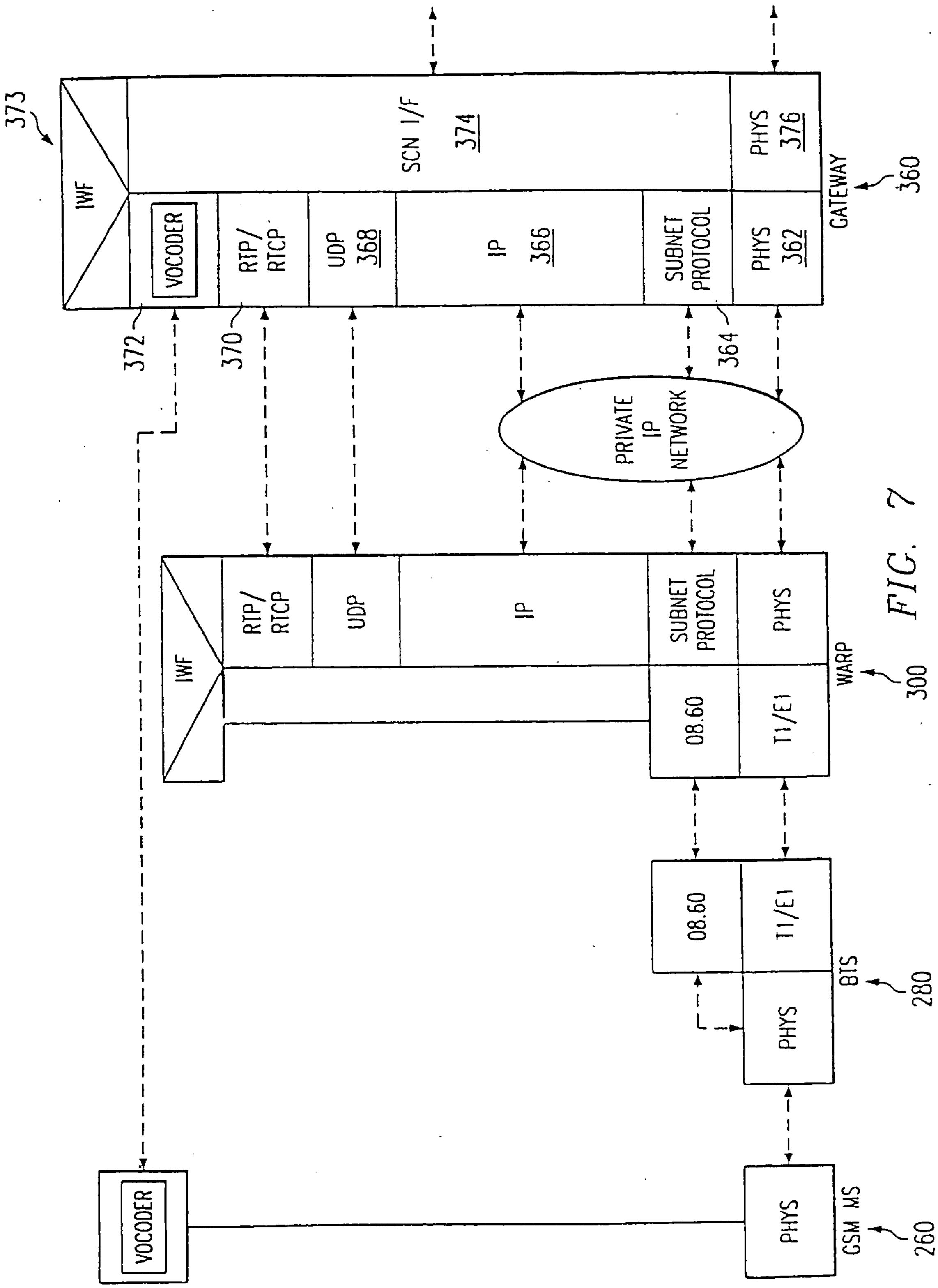
264
VOCODER
PHYS
262
GSM MS
260

FIG. 6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SCN I/F
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PHYS
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VOCODER
RTP/
RTCP
UDP
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IP
366
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PROTOCOL
PHYS
362
GATEWAY
360
372
370
364
PRIVATE
IP
NETWORK
IWF
RTP/
RTCP
UDP
IP
SUBNET
PROTOCOL
PHYS
08.60
T1/E1
WARP
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T1/E1
PHYS
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PHYS
GSM MS
260

FIG. 7

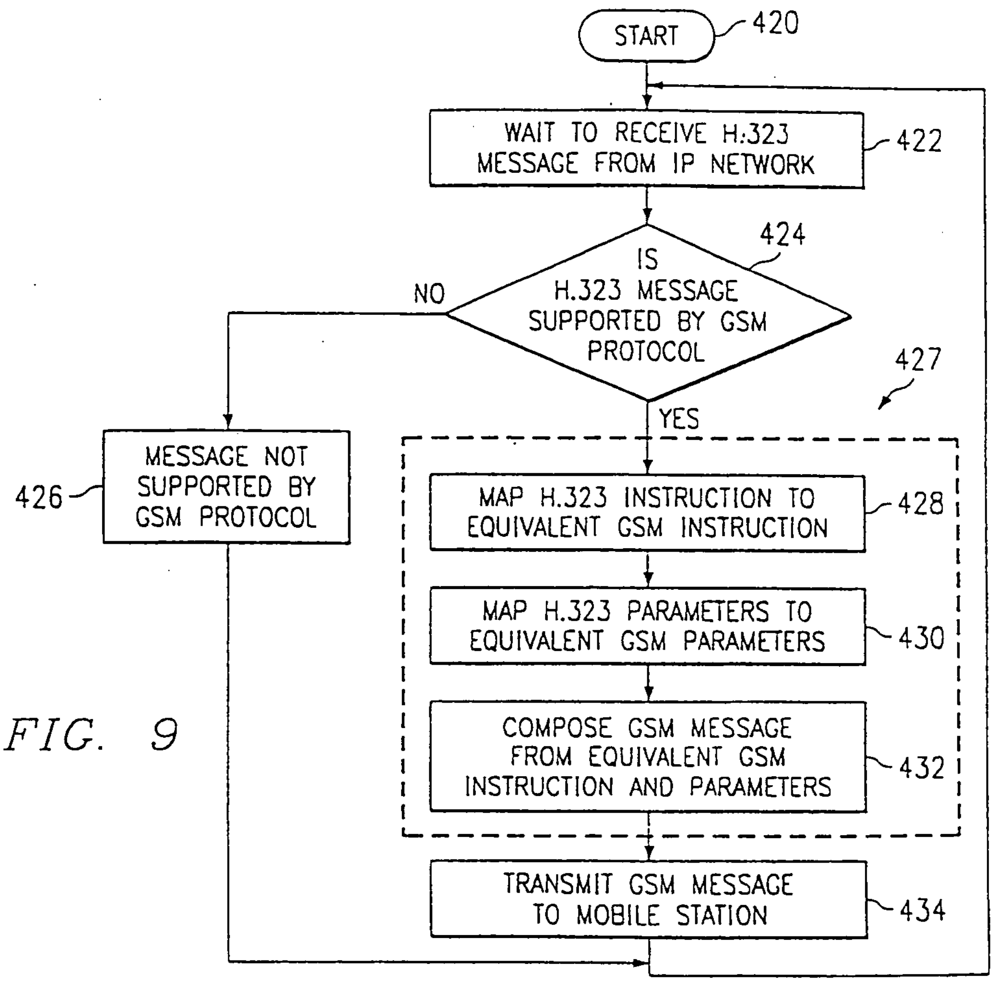
START
420
WAIT TO RECEIVE H.323 MESSAGE FROM IP NETWORK
422
IS H.323 MESSAGE SUPPORTED BY GSM PROTOCOL
424
NO
YES
427
MESSAGE NOT SUPPORTED BY GSM PROTOCOL
426
MAP H.323 INSTRUCTION TO EQUIVALENT GSM INSTRUCTION
428
MAP H.323 PARAMETERS TO EQUIVALENT GSM PARAMETERS
430
COMPOSE GSM MESSAGE FROM EQUIVALENT GSM INSTRUCTION AND PARAMETERS
432
TRANSMIT GSM MESSAGE TO MOBILE STATION
434

FIG. 9

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/02573

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 99 05830 A (ERICSSON TELEFON AB L M) 4 February 1999 (1999-02-04) page 3, line 30 -page 4, line 31 page 8, line 15 - line 16 page 11, line 19 - line 27 ---	1-6,8-20 7
A	"DIGITAL CELLULAR TELECOMMUNICATIONS SYSTEM (PHASE 2+);IN-BAND CONTROL OF REMOTE TRANSCODERS AND RATE ADAPTORS FOR ENHANCED FULL RATE (EFR) AND FULL RATE TRAFFIC CHANNELS(GSM 08.60 VERSION 7.0.1 RELEASE 1998), EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE" EUROPEAN TELECOMMUNICATION STANDARD,XX,XX, January 2000 (2000-01), pages 1-31, XP002171819 page 1, line 3 - line 6 --- -/--	3,4

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 July 2001	27/07/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Palencia Gutiérrez,C

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Intern   al Application No
PCT/US 01/02573

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	SMITH D R ET AL: "INTEGRATION OF WIRELESS TECHNOLOGY IN THE DEFENSE INFORMATION SYSTEM NETWORK (DISN)" ANNUAL MILITARY COMMUNICATIONS CONFERENCE,US,NEW YORK, IEEE, vol. 15TH, 22 October 1996 (1996-10-22), pages 389-393, XP000697309 ISBN: 0-7803-3683-6 the whole document -----	7

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inten nal Application No
PCT/US 01/02573

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9905830 A	04-02-1999	AU 8363298 A	16-02-1999
		BR 9810781 A	25-07-2000

Form PCT/ISA/210 (patent family annex) (July 1992)